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A DYNAMIC CLUSTER FORMATION FOR QUERY-BASED DATA AGGREGATION IN WIRELESS SENSOR NETWORK: A SURVEY

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ABSTRACT

In this paper, dynamic cluster formation for certain situation where sink wants information from some of the sensor nodes at a particular region is addressed. In clustering based data aggregation technique, dynamic clustering approach is preferred than static clustering approach. The main focus is on selection of cluster head for data aggregation as well as routing the information to sink. This paper gives three different methods for deciding cluster head and tries to reduce the tradeoff between energy consumption and end to end delay.

KEYWORDS: Wireless Sensor Networks, Data Aggregation Techniques, Static and Dynamic Clustering, Cluster Head Selection

I. INTRODUCTION

Wireless sensor networks (WSNs) have received attention increasingly in recent years. A Wireless Sensor Network contains hundreds or thousands of sensor nodes scattered in a sensor field, which is an area where the sensor nodes are deployed. Basically, each sensor node comprises sensing, processing, transmission, mobility, position finding system, and power units. In WSN, when event is generated, the sensor nodes collect environmental information, such as temperature, atmospheric pressure and irradiation by providing ubiquitous sensing, computing and communication capabilities and send their collected information towards the sink.

The overall process consumes much energy at each sensor nodes. So the main objective is to reduce energy consumption at each sensor node to increase their life time. Data aggregation is a known technique which gives major impact on energy consumption. The details about data aggregation techniques and problems associated with them are explained in section II. After that we discuss about the dynamic clustering types and their comparative study in section III. After identifying a problem for certain situation in section IV, three methods are proposed in section V. Finally in section VI, we conclude the paper with a summary and discussion of future work.

II. RELATED WORK

Data aggregation techniques play an important role in increase network life time. It attempts to collect useful information from the sensors surrounding the event and then transmits only the useful information to the end point thereby reducing energy consumption, congestion and their associated problems, results in increasing the network life time. There is various data aggregation techniques exist in WSN as describe below:

- Tree-base data aggregation technique [1] in this technique the form of tree is minimum spanning tree, root node acts as a sink node which collects the information from their child node. Intermediate nodes aggregate the information received from their child nodes and forward it to their parent and leaf nodes are responsible to sense the information.

TAG [3]: The *Tiny Aggregation* (TAG) approach is based on aggregation trees and is specifically designed for *monitoring applications*. It has two phases: The *distribution phase*, where queries are disseminated to the sensors and the C*ollection phase*, where the aggregated sensor readings are routed up the aggregation tree. But TAG is inefficient in case of dynamic topologies or link/device failures.

As the topology changes, it needs to re-organize the tree structure and this means high costs in terms of energy consumption and overhead. In addition, Scalability and node mobility is low. Many algorithms were proposed like Directed Diffusion, PEGASIS, DB_MAC in tree based approach but no one could overcome these problems.

- *Cluster Based Data Aggregation Technique [1]* in cluster-based approach the whole network is divided into several clusters. Each sensor can transmit data to a local aggregator or cluster head which aggregate data received from cluster members locally and then transmit the result to base station (sink). The cluster heads can communicate with the sink directly via long range transmissions or multi hopping through other cluster heads. This results in significant energy savings for the energy constrained sensors.

LEACH [4]: *Low-Energy Adaptive Clustering: Hierarchy* (LEACH) is a self-organizing and adaptive clustering protocol using randomization to evenly distribute the energy expenditure among the sensors. This algorithm was one of the first major improvements on conventional clustering. It provides a balancing of energy usage by random rotation of CHs. The algorithm is also organized in such a manner that data fusion can be used to reduce the amount of data transmission. The decision of whether a node elevates itself to CH is made dynamically at each interval, to minimize overhead in CH establishment.

This decision is a function of the percentage of optimal CHs in a network (determined a priori on application), in combination with how often and the last time a given node was the CH. This scheduling scheme allows for energy minimization as nodes can turn off their radio during all but their scheduled time- slot. Therefore LEACH provides a uniform load balancing in one-hop sensor networks. Localized coordination scheme used in LEACH provides better scalability for cluster formation and better load balancing enhances the network lifetime. But there are various drawbacks for this protocol as:

- If the sink is placed far away from a cluster-head, a high power may be necessary to successfully deliver the message.
- It is not suitable in highly dynamic environment as continuous updates are needed in order to keep the clusters consistent with the underlying topology.
- In case of mobility a node close to a cluster-head at a given instant may move away from the cluster-head which results into the node needs to increase its power, thereby spending much more energy to transmit to the cluster - head than expected. To overcome these problems various extension to the LEACH are made like two level LEACH (TL-LEACH), Energy Efficient Clustering Scheme (EECS), LEACH-C, LEACH-F etc. All these techniques focussed on cluster head selection which is responsible for data aggregation to achieve optimum solution.

III. TYPES OF CLUSTERING

- **Static Clustering**

Statically clustered networks divide the network proactively into many clusters. A cluster would consist of many cluster nodes and a cluster head (CH). A CH can schedule or aggregate data from its cluster nodes. Any sensing events from cluster nodes are directly sent to the cluster head, which would aggregate data of all cluster nodes, remove redundant data, if necessary and send it towards the sink node.

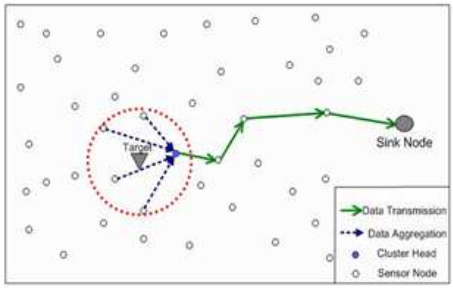

Figure 1: Static Clustering Based Data Aggregation

- **Dynamic Clustering**

Dynamically clustered network creates a cluster reactively in the surrounding area of the event sensing nodes. Upon event detection, a certain sensor node (preferably the one with the most energy or closest to the event) that has sensed a target will be elected as a cluster head, while all the other nodes that also sensed the target will become cluster nodes that are located in a single hop range of the cluster head. All the data are collected and aggregated by the cluster head, and then sent to the sink.

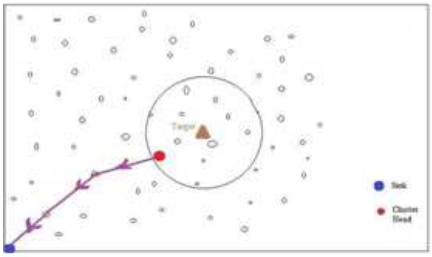

Figure 2: Dynamic Clustering Based Data Aggregation

- **Comparative Study**

o In static, data uses pre-elected cluster heads for data aggregation, so data can be quickly and easily transmitted to the sink node with relatively low overhead whereas in dynamic, clusters are made upon sensing of an event, so additional delay for electing a cluster head will occur before the transmission of the data.

o In static, More than one cluster may sense a target at the same time, reducing the data aggregation efficiency whereas Only one cluster sense a target at a time, increasing the data aggregation efficiency.

o When all the sensing is arranged inside one cluster, static clustering will show best aggregation results while in dynamic, all sensing is always in one cluster only so always gives the best aggregation result.

o All necessary and unnecessary nodes may participate in data aggregation, so energy utilization is less in static

which is not happen in case of dynamic as only necessary node will take part in aggregation.

- Data may have to travel many hops to be aggregated gives low aggregation rate in static whereas aggregation rate is high in dynamic clustering.
- Static cluster method can benefit when there are many targets or the target velocity is high, because proactively created clusters can be used without additional overhead. And dynamic clusters have to be frequently created when the velocity of a target is high. This may result in control packet overhead and data transmission delay.

IV. PROBLEM STATEMENT

It is necessary to develop an energy efficient dynamic cluster formation for Query-based data aggregation in Wireless Sensor Network. Consider a scenario where a sink will ask for the information at specific region (Ex. how many horses near the pond in forest). Here sink is interested to get the information from some nodes; not from all nodes. In such situation none of the above mentioned protocols will work as they process all nodes. In addition choosing aggregator (CH) is very important because no node has global knowledge of the network.

There are two important factors to choose aggregators: Energy level and distance to sink. Selecting a node with highest energy as an aggregator for energy balancing may not be at the minimum distance from the base station. On the other hand, selecting a node with minimum distance from sink as an aggregator for reducing an end-to-end delay may not have the needed energy for processing. Unfortunately, choosing the node with optimal energy level and distance both is difficult. They study the trade-off between data aggregation and latency in WSNs. So this trade-off need to be reduces to achieve optimal data aggregation technique and routing strategy as well.

V. METHODOLOGY

There are three types of methodology to choose cluster head in dynamic cluster based data aggregation in WSN as follows:

- **Distance Based**

In this method, the selection of cluster head depends upon the distance between cluster nodes and sink. Here the cluster head is the one who is nearer to sink. The figure 3 shows that cluster head is near the boundary of cluster region which is at three hope distance from the sink.

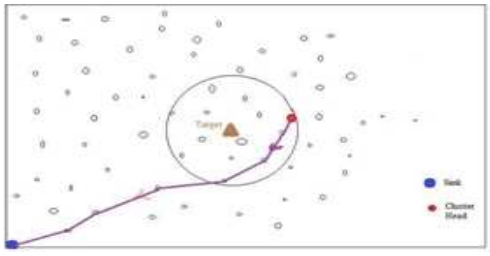

Figure 3: Distance-Based Method

The node which acts as an aggregator need not be selected as a cluster head every time because cluster region may get change for every sink request. But here the problem is that we blindly select cluster head without knowing whether he is capable to become cluster head or not. It may possible that the cluster head may not have sufficient energy to do the aggregation and send aggregated value to the sink.

- **Energy Based**

In this method, the selection of cluster head depends upon energy at each cluster node. Here the cluster head is the one who has the highest energy than others. The figure 4 shows that cluster head is at seven hope distance from the sink.

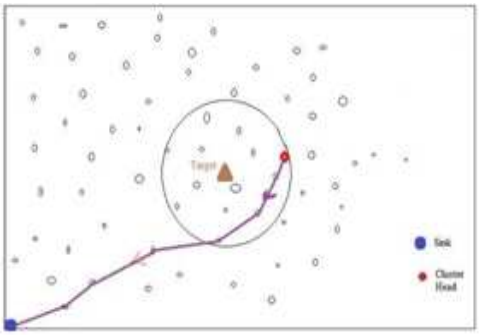

Figure 4: Energy-Based Method

The figure 5 shows that the cluster head is at four hope distance from the sink and we can trust on the cluster head as well. Here the major difficulty is to identifying the cluster head node as we don't know the global knowledge of sensor field.

This method solves the problem of location based approach. Here cluster head is surely capable of doing aggregation and sending the aggregated data back to the sink surely. But this also have one serious problem of performance. If sink doesn't get the result on time (end-to-end delay) then this method is not suitable.

- **Hybrid Method**

Taking advantages from both the above methods, we combine these two methods so that we can able to solve the tradeoff between data aggregation and latency in WSNs. In this method, we select a cluster head by considering both its energy and its hop distance from sink.

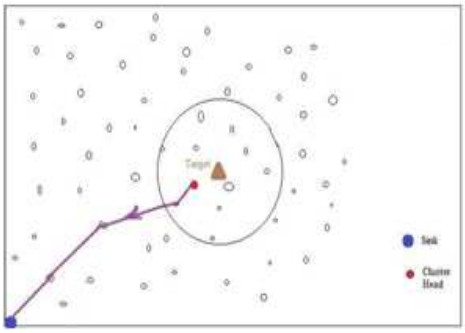

Figure 5: Hybrid Method

VI. CONCLUSIONS AND FUTURE WORK

Optimizing the trade-off between energy consumption and end to end delay for data aggregation is an interesting and challenging issue in WSN. The given three methodologies based on dynamic clustering which tries to solve the trade-off between energy and end to end delay(latency) in network. In future, we focus on simulation of all the proposed methods and their comparative study to find the best one which gives optimal solution.

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